LA-12551-MS

Storage of Plutonium Extracted from Weapons (U)

J. M. Haschke
J. C. Martz

March 12, 1993

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

III. Fundamental Plutonium Properties

Knowledge of certain nuclear, chemical, and physical properties of plutonium and relevant compounds is essential for evaluating candidate storage forms, for addressing ES&H concerns, and for examining other technical issues. In addition to the ^{239}Pu isotope that simultaneously undergoes alpha decay ($t_{1/2}$ = 2.4 x10^4 years) and spontaneous fission ($t_{1/2}$ = 5.5 x10^{15} years), weapons-grade material contains small amounts of other plutonium isotopes including ^{241}Pu. Beta decay of ^{241}Pu ($t_{1/2}$ = 13.2 years) leads to in-growth of ^{241}Am that decays at a slower rate ($t_{1/2}$ = 458 years) with emission of an energetic (60 keV) gamma ray. From a chemical perspective, Pu is an active metal that reacts with most other elements and materials.[6] Plutonium reacts with oxygen, air, water and many oxygen-containing compounds to form Pu_2O_3 and PuO_2. Although dioxide is the more stable of these products and is considered to be the equilibrium phase in air, recent observations for reaction of Pu with water vapor show that the most stable oxide is near $PuO_{2.2}$, a mixed-valent compound with $Pu(IV)_4Pu(VI)O_{11}$ stoichiometry.[7] Plutonium dioxide has an active surface and strongly absorbs molecules like H_2O and CO_2. Depending on the method of oxide preparation, large variations in surface area (from less than 0.1 to more than 60 m^2/g, typically 10 m^2/g), particle size, and bulk density are observed.[8,9,10] Other compounds of interest include plutonium carbides (PuC, Pu_2C_3, PuC_2) and plutonium nitride (PuN). These materials are

---

[6]J.M. Cleveland, "The Chemistry of Plutonium," American Nuclear Society, La Grange Park, IL 1979. See also O.J. Wick, ed., "Plutonium Handbook, A Guide to the Technology - Volumes I and II," American Nuclear Society, La Grange Park, IL 1980.

[7]J.L. Stakebake, D.T. Larson, and J.M. Haschke, "Characterization of the Plutonium-Water Reaction Part II: Formation of a Binary Oxide Containing Pu(VI)," Los Alamos Report LA-UR-93-0040, January 1993 (unclassified). Submitted for publication in J. of Metals and Alloys.

[8]J.D. Moseley and R.O. Wing, "Properties of Plutonium Dioxide," Rocky Flats Report RFP-503, August 24, 1965 (unclassified).

[9]J.M. Haschke, "Evaluation of Source-Term Data for Plutonium Aerosolization," Los Alamos Report LA-12315-MS, July 1992 (unclassified).

[10]J.L. Stakebake and M.R. Dringman, J. Nucl. Mat., 23 (1967) p. 349.

IV. Ease of Reconstitution

The perceived difficulty in reconstitution of a particular form is often used as justification for processing to and storage of that form. Hence, it is of foremost importance to consider the ease with which plutonium can be reconstituted. Reconstitution of plutonium from a variety of forms has been addressed in several studies. A joint DOE task force examined this issue in detail in 1977 and 1978.[16,17] Our own technical assessment of reconstitution issues is in agreement with the conclusions of the DOE study.[18] The purpose and scope statement from that report reveals the comprehensive nature of the study.

> The purpose of this study is to assess the potential usefulness of materials in the licensed reactor industry as fissile materials for the construction of nuclear explosives. A comprehensive list of materials has been considered in order that the scope of the study not be limited by too specific constraints. The list was drawn from the present and possible future reactor industry sources and from the nuclear weapons program.
>
> The results of the study provide an overall framework for assessing the usability of reactor materials for nuclear explosives. Broad categories have been defined which are related to the technical difficulty of using various materials, and all the materials have been placed in these categories.

---

[14]D.R. Harbur, J.W. Romero, and J.W. Anderson, "Plutonium-Cerium-Cobalt Fuel Development for Molten Reactors," AFS Meetings: Modern Castings, **48** (1965) p. 124.

[15]D.R. Harbur, J.W. Anderson, and W.J. Maraman, "Studies on the U-Pu-Zr Alloy System for Fast Breeder Reactor Applications," Los Alamos Report LA-4512, November 1970.

[16]W.J.Ogle (DOE/OMA), T.J.Hiirons (LANL), J.C.Mark (NRC), W.C.Myre (SNLA), and R.W.Selden (LLNL), "A DOE Special Study Report: Reactor Materials and Nuclear Explosives (U)," DOE Report DOE/DP-0003, February 1978 (Confidential NSI).

[17]A secret version of the previous reference is available: W.J.Ogle (DOE/OMA), T.J.Hiirons (LANL), J.C.Mark (NRC), W.C.Myre (SNLA), and R.W.Selden (LLNL), "A DOE Special Study Report: Reactor Materials and Nuclear Explosives (U)," DOE Report DOE/DP-0002, February 1978 (Secret/RD).

[18]The difficulty of reconstitution is often speculated upon by analysts unfamiliar with the details of plutonium processing. The distinguished study group which addressed this issue included experts intimately familiar with various plutonium processing operations. Considerable conjecture has occurred which is in conflict with the results of our and the study group's assessment. We consider the issue of reconstitution important enough to show detailed results from Ogle et al., and hope this examination presents the technical issues in a manner free from speculation or bias.

DoE
b(3)

Indeed, "the fact that Pu containing more than 8% Pu-240 (reactor grade) can be used to make nuclear weapons" is unclassified.[27] However, the "isotopic composition of the Pu fuel in a designated weapon" is SRD "if it contains more than 8% Pu-240." Bob Selden (ref. 25) notes

> The concept of 'denatured' plutonium – plutonium which is not suitable for explosives – is fallacious. A high content of the plutonium 240 isotope is a complication, but not a preventative.

DoE
b(3)

These statements are supported by considerable background data, a summary of which is given here.[28]

DoE
b(3)

[26]J.C. Mark, "Use of Reactor Grade Plutonium in Weapons (U)," Los Alamos Report LA-3287-MS, April 8, 1965 (Secret/RD).

[27]"Guide to Classification of Technical Information (U)," LA-4000, Rev. 6 (Secret/RD).

[28]Much of this discussion taken from J.W. Gordon, Los Alamos internal memorandum IT-2(S)-92-380, "Notes of the Nonproliferation Nuclear Weapons Working Group", December 4, 1992. (Secret/RD)